

Magma sources in the Icelandic Western Rift Zone (WRZ): Crustal and mantle input

R. C. J. STEELE, M. F. THIRLWALL, C. J. MANNING,
M.A.M. GEE, M. REGELOUS AND D. LOWRY

Department of Geology, Royal Holloway, University of
London, Egham, Surrey, TW20 0EX, UK

Low $\delta^{18}\text{O}$ Icelandic rift basalts have been interpreted as a result of contamination by low $\delta^{18}\text{O}$ crust, or as derived from an unusual, low $\delta^{18}\text{O}$ mantle source. In the Reykjanes Peninsula (RP) $\delta^{18}\text{O}_{\text{OL}}$ values $\geq +4.2$ ‰ have been interpreted as mantle derived, while lower values were thought to reflect contamination [1]. ($^{230}\text{Th}/^{238}\text{U}$) disequilibrium has also been used as an indicator of crustal contamination in both rift, and off-rift zones in Iceland [2]. Since the magnitude of ($^{230}\text{Th}/^{238}\text{U}$) disequilibrium varies radially with proximity to the proposed centre of the Iceland plume [3], variations in ($^{230}\text{Th}/^{238}\text{U}$) may however, reflect melting parameters rather than crustal contamination.

The WRZ is an ideal area to study the extent to which low $\delta^{18}\text{O}$ and ($^{230}\text{Th}/^{238}\text{U}$) disequilibrium indicate crustal contamination, due to their eruption during post/last-glacial time minimizing the need for an age correction. Further, the rift zone is orientated tangentially to the assumed location of the centre of the plume, and thus variations in extent of disequilibrium cannot be strongly controlled by distance to the plume.

A study of new O-Sr-Nd-Pb data from the WRZ demonstrates $\delta^{18}\text{O}$ as low as $+3.79$ ‰ in primitive lavas (9.5 % MgO, $^{143}\text{Nd}/^{144}\text{Nd}$ 0.513046). The WRZ data appear compatible with varying degrees of crustal contamination in terms of $\delta^{18}\text{O}$ and $^{143}\text{Nd}/^{144}\text{Nd}$. However, assuming the WRZ assimilant has a $\delta^{18}\text{O}_{\text{OL}}$ of $+1.2$ ‰ [1] then 35 % bulk assimilation is required to produce the lowest $\delta^{18}\text{O}_{\text{OL}}$ sample of 3.79 ‰ from the mantle mean of 5.2 $\delta^{18}\text{O}_{\text{OL}}$. This is difficult to reconcile with the relatively low degrees of fractional crystallization, shown by the 9.52 % MgO found in this sample.

Isotopic data from Hengill central volcano, located at the triple junction between the WRZ, RP and the south Iceland seismic zone (SISZ), plot at the enriched end of WRZ Nd-Sr-Pb trends, showing the sources are isotopically linked. $\delta^{18}\text{O}_{\text{OL}}$ from Hengill is $3.83 - 4.5$ ‰, with $5.91 - 8.73$ % MgO. This range is present in rocks with homogenous Nd-Sr isotope ratios, showing that Hengill is much more consistent with assimilation producing the low $\delta^{18}\text{O}$ signature.

References

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The hydrolysis and chloro complexation of iron(III) in hydrothermal solutions

A. STEFANSSON¹, T.M. SEWARD² AND I. GUNNARSSON¹

¹Institute of Earth Sciences, University of Iceland, Sturlugata
7, 101 Reykjavik, Iceland

²Institut für Mineralogie und Petrographie, ETH-Zentrum,
Universitätstrasse 16, 8092 Zürich, Switzerland

A knowledge of the stability of iron(III) hydroxide and chloride complexes in hydrothermal solutions is important for quantitative interpretation of the transport and precipitation of iron by crustal fluids. It is generally accepted that iron is predominantly transported as iron(II) species in reduced hydrothermal fluids in the Earth's crust. However, boiling (phase separation) occurs ubiquitously in hydrothermal systems with the partitioning of hydrogen into the volatile (less dense) phase. The redox state of the residual liquid (or denser phase) and pH changes, such that iron(III) may become the predominant oxidation state of iron. A knowledge of the complex equilibria involving Fe^{3+} is therefore important in understanding the transport and precipitation chemistry of iron by fluids in the crust at high temperatures and pressure.

The complexation of iron(III) with hydroxo and chloro ligands has been studied as a function of solution composition (salinity and pH) in hydrothermal solutions to 300°C at saturated water vapour pressure. Two experimental methods have been applied, uv-vis spectrophotometry using a high-temperature, flow-through gold-lined optical cell and hematite solubility using flow-through and static autoclave systems. The strong ligand-to-metal charge transitions of the uv-vis spectra of iron(III) hydroxo and chloro complexes at wavelengths below 400 nm were used to obtain molar absorptivities, ϵ , and equilibrium formation constants using principle component analysis and non-linear least squares treatment of the hematite solubility measurements were used to obtain solubility constants. Based on the experimental result iron(III) was found to hydrolyse to form FeOH^{2+} , $\text{Fe}(\text{OH})_2^+$, $\text{Fe}(\text{OH})_3(\text{aq})$ and $\text{Fe}(\text{OH})_4^-$ with increasing pH and FeCl_2^+ , $\text{FeCl}_3(\text{aq})$ with increasing chloride concentration in acid solutions. Iron(III) hydroxide complexes were found to predominate in dilute and alkaline hydrothermal solutions whereas with increasing chloride concentration and temperature iron(III) chloride complexes become increasingly important species in oxidised acid solutions.